

ECONOMICS OF MALARIA

Plenary Presentation

Is Malaria Control Cost-Effective?

Anne Mills

Breakout Sessions

Programme

1. Demand for Malaria Treatment and Prevention.
2. Supply Issues and Markets
3. Public Policy

Summary Report

PLENARY PRESENTATION

Is Malaria Control Cost-Effective?

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Introduction

As an economist, I am most grateful for the invitation to speak at the start of this important meeting, and particularly glad of the recognition that economics has much to offer both researchers and control programmes who seek to tackle the burden of malaria. A number of you may be concerned that I am going to present puzzling demand and supply curves, show strange equations, or talk about choosing between apples and pears (for those of you not familiar with elementary economics, issues of choice are often introduced in this way). I am going to do none of that, but rather to present the key messages from recent work on the economic burden of malaria and the cost-effectiveness of malaria control. I will end by highlighting key research needs identified by the economic analysis. This presentation draws on recent research conducted by our group at the LSHTM, and supported by the Global Forum for Health Research¹.

I want first to introduce the concept of cost-effectiveness, for those of you not completely familiar with it. The essential point is a simple one: that we cannot decide on whether an intervention or programme is worth supporting unless we have information on not only its effectiveness but also its cost. Since resources are scarce, putting money into one activity is always at the expense of not doing something else. Therefore simply knowing that we have a new technology that works is not sufficient to decide to spend money on it. We must compare the costs and effects of the new technology, with the costs and effects of additional investment in other services. Thus research on the costs of an intervention is as important as research on its effectiveness (and I might add for research funders, much less costly to fund). Costs are divided by health effects to obtain a cost per unit of health effect, known as the cost-effectiveness ratio.

There is a further consideration that economic analysis can take into account. This is that diseases give rise to an economic burden on individuals and governments, and that disease reduction can therefore produce savings in resources. The simplest example is where individuals spend money on treatment of malaria, but if a mosquito net programme reduces malaria incidence, there are benefits in the form of reduced expenditure. There are also likely to be more general economic development benefits arising from malaria control.

Knowledge on the cost-effectiveness of malaria control is more advanced than knowledge on the economic burden of malaria and economic benefits of control. I am therefore going to spend only a short amount of time on economic burdens and benefits, before considering the cost-effectiveness of control measures.

¹ Goodman C, Coleman P, Mills A (1999) The cost-effectiveness of malaria control in sub-Saharan Africa. *Lancet* (in press). Chima R, Goodman C, Mills A The Economic Impact of Malaria in Africa: a critical review of the evidence. *Bull WHO*, submitted.

The economic burden of malaria

There are very good grounds for supposing that malaria has adverse consequences for economic development. There are some key mechanisms through which this occurs. These include:

- 1 the detrimental impact of malaria on the ability of people to work hard, either because they themselves are sick or because their children are sick
 - 2 the effect of malaria on child development and ability to benefit from schooling
 - 3 the economic costs of the impact on land use, if land goes uncultivated because workers are sick
 - 4 expenditure on treatment and prevention by households and the public health sector.
- I want to say a little more about some of these.

We know that malaria affects the time and effort that households can put into production, and that the main period of transmission can coincide with peak demands for labour. There is also evidence that malaria can cause children to be absent from school. However, there are also more pernicious effects on child development and ability to benefit from education. Malaria is known to be an important cause of anaemia, epileptic convulsions, growth faltering, and neurological sequelae. These are all likely to affect children's performance at school, and we know from the literature on the economics of education that a less educated child is a less productive adult. Hence the effect of malaria on children is likely to persist into adulthood.

In terms of expenditure on treatment and prevention, sometimes substantial sums are spent by households. Figure 1 shows monthly household per capita expenditure on treatment related to malaria. Amounts range up to \$4 per capita per month, and are particularly high in urban areas. Similar evidence of expenditure on goods that may offer protection against malaria and mosquitoes (Figure 2) suggests sums of up to \$2 per person per month.

Figure 1:
Monthly per capita
expenditure by
households on
malaria-related
treatment

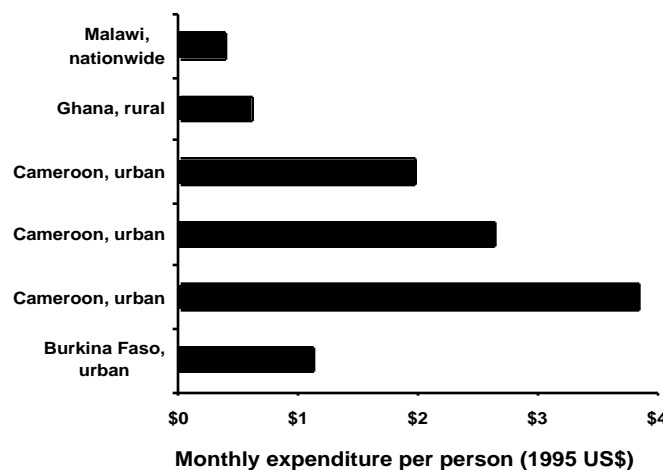
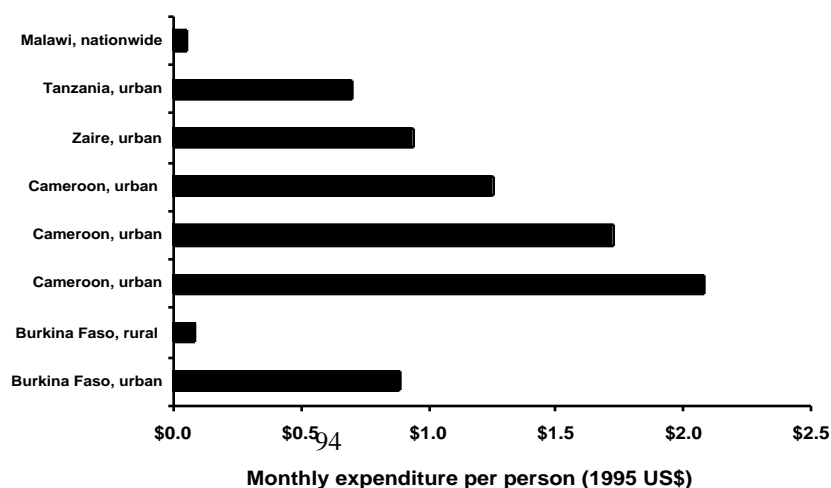


Figure 2:
Monthly per capita
expenditure by
households on



protection against malaria/mosquitos

The burden on the public health system is best demonstrated by evidence of the burden on peripheral health facilities. For example, around 20-40% of outpatient visits in SSA are for 'fever'², and suspected malaria amongst inpatients ranges from between 0.5% to 50% of admissions. Treating an outpatient for suspected malaria cost around \$1 in government and mission facilities in Malawi (Ettling & McFarland 1992), and inpatient treatment for severe paediatric malaria cost \$64 per admission in the Kilifi district hospital in Kenya, and \$34 in the adjacent Malindi sub-district hospital (Kirigia *et al.* 1998). Kirigia *et al.* also estimated that 15% of the annual recurrent costs of inpatient care in the Kilifi district hospital, and 9% in Malindi, were absorbed by paediatric malaria admissions.

More generally, malaria may have a pervasive effect on the economic incentives, behaviour and strategies of households. Households may, for example, limit the specialisation of labour and maintain labour reserves to reduce the risk of labour shortages at key times of the year. This may protect them from catastrophic losses, but will also reduce productivity. Households may be reluctant to invest in productive activities or child schooling, again depressing productivity, especially in the longer term.

Recent work, which uses economic growth models to assess the effect of malaria prevalence on depressing economic growth rates, suggests that there are indeed likely to be pervasive effects. Work in progress by Gallup and Sachs is exploring macro-economic impact by including a measure of malaria as an explanatory variable in economic growth models (Gallup & Sachs 1998). Preliminary results suggest that countries with substantial falciparum malaria in 1965 grew 1.3% per year less over the next 25 years. This analysis controlled for other influences on growth including tropical location and life expectancy as a measure of general health. A 10% reduction in malaria over the period was associated with 0.3% higher growth per year.

These findings highlight the need to develop a more detailed understanding of the mechanisms by which malaria affects households and economies. Such research will support advocacy for malaria control. However it can also be used to target control interventions. Better information on economic impact is required to identify the population groups and regions most at risk of adverse economic effects. For example, it is remarkable that good information is lacking on the relative incidence of malaria by socio-economic group, and especially its impact on the poorest. Appropriate economic impact data could also be used to identify the interventions which make the largest contribution to reducing the economic burden. For example preventive interventions which reduce transmission levels could have a significant impact on increasing economic incentives for investment and saving.

The cost-effectiveness of malaria control interventions

I said at the start that prior to decisions on spending money on a particular intervention, it is vital to know its cost in relation to its effectiveness. A small number of cost-effectiveness studies have been done: Table 1 summarises the evidence-base. In addition, a variety of other studies have produced evidence either on costs or on effects, and Table 2 summarises the overall availability of evidence. There are some key problems in using these data to inform

² The proportion of these that are actually malaria will vary greatly by area and season

overall policy. In particular, country coverage is haphazard, and relates to where the main research institutions are located. Thus there is better evidence on The Gambia and Malawi, for example, than elsewhere. In addition, cost-effectiveness studies have not always been done in a way that facilitates a judgement on their relevance to other settings. For example, most studies produce what is called a single point estimate of cost-effectiveness, and undertake only limited analysis of a plausible range for the cost-effectiveness ratio.

Table 1: Number of cost-effectiveness analyses available on malaria interventions

Type of intervention	Number of cost-effectiveness studies
ITNs	6
Residual spraying	1
Prophylaxis for children	1
Antenatal prophylaxis	3
Improving treatment	2
Environmental management	0
Control of epidemics	0

Table 2: Availability of evidence for estimating costs and effectiveness

Intervention	Health Outcomes	Costs
ITNs	***	***
Residual spraying	**	*
Prophylaxis for children	*	*
Antenatal prophylaxis	**	*
Improving treatment	*	*
Environmental control	-	-
Control of epidemics	-	-

Key:

- nothing
- * very limited (one or two studies)
- ** fair (several studies)
- *** good (several studies from a variety of settings)

We have been engaged in research designed to use available data to estimate cost-effectiveness in a form useful to policy makers and programme managers and which enables operational research priorities to be identified. Because of lack of information on other interventions, those interventions we have been able to evaluate are:

- Preventing malaria in childhood (insecticide treated nets, residual spraying of houses, chemoprophylaxis)
- preventing malaria in pregnancy (chloroquine chemoprophylaxis, sulphadoxine-pyrimethamine (SP) intermittent treatment for primigravidae)
- improving treatment of uncomplicated malaria (improving compliance with drugs, improving the availability of second and third line drugs, changing the first line drug for treatment).

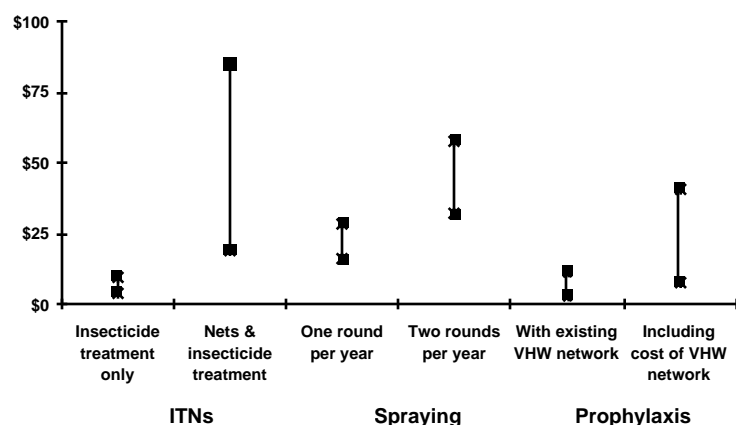
Before presenting the results, I want to highlight some key features of our methodology:

- we used a modelling approach to provide a consistent framework for the analysis of the various interventions, and to produce comparable estimates of cost-effectiveness
- we derived our data on effectiveness as far as possible from randomised controlled trials, but adjusted them to estimate operational effectiveness using compliance rates recorded in more realistic settings
- where the information allowed and when relevant to the intervention, we did separate calculations for low and high transmission areas, and perennial and seasonal transmission
- we used the disability adjusted life year as our unit of outcome: the DALY, as it is known, is a measure of health outcome which incorporates both premature death and morbidity/disability. It is useful because it enables interventions with differing effects on mortality, morbidity and disability to be compared
- since some costs such as salaries differ systematically by level of economic development, we also did separate calculations for countries in 3 income groups. In this categorisation, Tanzania, for example, is a very low income country, Cameroon a middle income country, and South Africa a higher income country
- we calculated the cost of adding the intervention to an existing delivery system, and included costs to both the government and individuals. Cost data were obtained through reviews of published and unpublished literature, and consultation with researchers and programme managers
- we used a method called probabilistic sensitivity analysis to produce cost-effectiveness ranges – this involves specifying a range and distribution for each variable in the models, and then running the models many times to generate a cost-effectiveness distribution. Summary indicators calculated were the mean and range within which 90% of the cost-effectiveness ratios fell.
- In order to interpret the results, we relied on guidelines used by WHO to interpret cost-effectiveness ratios. These guidelines state that in low income countries, an intervention is considered “highly attractive” if the cost per DALY falls below \$25-30, and “attractive” if it falls below \$150 (WHO 1996).

I want now to present the results. To simplify the presentation, I will show results only for a very low income country with high transmission. As I show the cost-effectiveness ranges, I will provide more detail on the specific nature of the intervention evaluated. Figure 3 shows the results for interventions to prevent malaria in childhood. The analysis of insecticide treated nets assumed treatment with the insecticide deltamethrin on a communal basis.

Figure 3: Cost-effectiveness of prevention of malaria in childhood

Two possible scenarios were considered: firstly, where nets were distributed to households as part of the programme, and secondly where treatment was arranged for existing nets. Estimates of effectiveness were drawn from the Cochrane meta-analysis of African trials, and were adjusted to account for lower net retreatment rates in operational settings.



Residual spraying calculations assumed a government-run programme and the insecticide lambda-cyhalothrin. In the absence of recent evidence on the health impact of residual spraying, it was necessary to rely on infant mortality reductions recorded during three controlled trials in the 1950s and 1960s. No health effects outside this age group or any reduction in morbidity could be included.

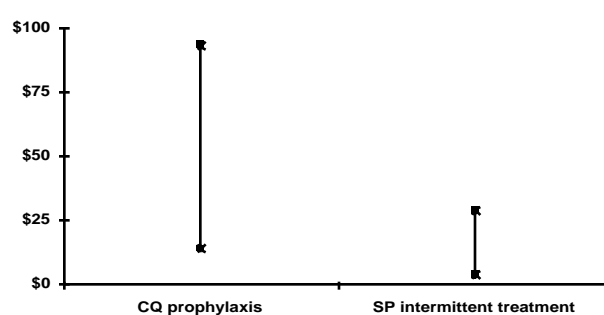
The chemoprophylaxis for children intervention consisted of the fortnightly distribution of the antimalarial, Maloprim® to children aged 6 to 59 months by village health workers under two scenarios: one where a network of volunteers existed already and one where it was necessary to establish a cadre to run the programme. Evidence on effectiveness was based on a Gambian trial which had used Maloprim, and was adjusted by realistic compliance estimates.

Figure 3 shows that all these interventions represent attractive use of resources, and highly attractive where nets already exist in communities and do not need to be purchased, and where there is an existing health worker network to give prophylaxis. An immediate reaction of some of you may be that there are a whole range of problems in implementing these interventions in practice: I do not wish to minimise these, but rather to point out that given the level of cost-effectiveness, it is worth putting in substantial effort to overcome the problems.

The intervention to prevent malaria in pregnancy consisted of two alternative drug regimens for primigravidae only: weekly chloroquine chemoprophylaxis; or two intermittent treatments with sulfadoxine-pyrimethamine. Their effectiveness drew on a meta-analysis of chemoprophylaxis which found a significant increase in the birth weight of children born to primigravidae (but not to multigravidae). The sample sizes of the studies were too small to demonstrate a significant impact on neonatal mortality, so the impact was modelled based on birth weight distributions and birth weight specific neonatal mortality rates.

Figure 4: Cost-effectiveness of prevention of malaria in pregnancy

Figure 4 shows again that this intervention is highly cost-effective, especially the regimen involving sulfadoxine-pyrimethamine. I should note that these calculations assume a certain level of resistance to the two drugs, and that re-running the calculations assuming different levels of resistance showed that the conclusions were robust to plausible resistance levels.



Three interventions to improve case management were evaluated:

1. improving compliance with chloroquine through training of providers, health education for patients and care-takers, and the pre-packaging of chloroquine in plastic bags. These reduce the probability of failure of the first line drug, thus increasing the proportion of cases cured overall and reducing morbidity and mortality
2. improving the availability of second and third line drugs so cases of treatment failure with the first line drug, namely chloroquine, can be prescribed alternatives, namely sulfadoxine-pyrimethamine, then quinine

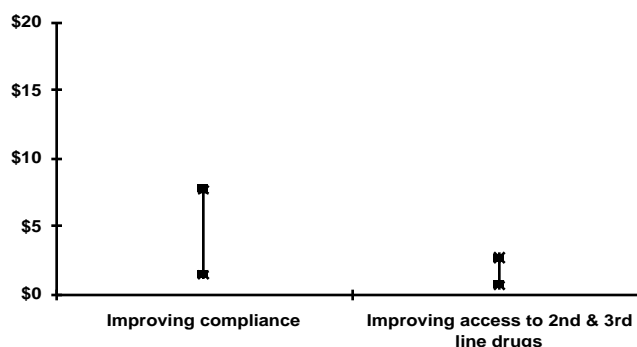
- changing the first line drug for the treatment of uncomplicated malaria from a regimen where chloroquine is the first line drug, sulfadoxine-pyrimethamine the second line drug and quinine the third line, to a regimen where sulfadoxine-pyrimethamine is the first line drug, amodiaquine the second line, and quinine remains the third line.

Few evaluations of interventions to improve treatment include evidence on health outcomes, so a decision tree model was developed to translate changes in intermediate outcomes, such as compliance and drug efficacy, to final health outcomes. For those of you unfamiliar with decision tree analysis, it traces the possible paths a patient could follow who presents at an outpatient facility with suspected uncomplicated malaria. Probabilities are attached to each branch. For example, a patient with treatment failure may either remain with uncomplicated malaria, or develop severe disease. If the latter, they may or may not seek admission to hospital. Each path is traced to the final health outcomes of death, survival with neurological sequelae, or full recovery.

Figure 5 shows that the first two interventions are highly cost-effective. Indeed, the scale of the graph has been enlarged to show them clearly. Although lack of data prevented us doing similar calculations for improving treatment of severe malaria, I strongly suspect that this would be similarly cost-effective.

Figure 5: Cost-effectiveness of improving case management

We also evaluated the decision to change the first line drug. At given levels of drug resistance, a switch from chloroquine to sulfadoxine-pyrimethamine appears highly attractive. However, this static analysis ignores concerns that resistance to sulfadoxine-pyrimethamine will rapidly increase once it is widely adopted, and that affordable alternative antimalarials will not be available. Analytical methods must therefore allow



for the growth of drug resistance over time, and incorporate trade-offs between higher drug costs, immediate reductions in morbidity and mortality, and potential increases in resistance to replacement drugs which could lead to higher morbidity and mortality in the future. For these reasons it is not possible to summarise the intervention in a single cost-effectiveness ratio. However, when growth in resistance is allowed for, the model suggested that it may be optimal to wait several years before switching, at the short term cost of higher morbidity and mortality. A key difficulty in undertaking this analysis is that so little is known about the growth rate of resistance over time.

Conclusions

The central message to policy makers and programme managers from this work is that highly cost-effective interventions exist to help control malaria. There are clearly innumerable problems to be faced in putting these interventions in place and expanding their coverage, not least issues of acceptability and drug and insecticide resistance. However, effort can clearly be justified on the grounds that these interventions are just as good value for money as immunisation programmes, for example.

This analysis also highlights that the most cost-effective mix of interventions will vary from place to place. Cost-effectiveness is affected by a variety of factors, not least on the cost side the level of existing infrastructure, input prices, and the scale of activity; and on the effectiveness side epidemiological and demographic factors, and capacity to implement an effective programme. In addition, acceptability of the intervention to local people affects both costs and effectiveness. Country level analysis is thus needed to feed into decisions on country policy.

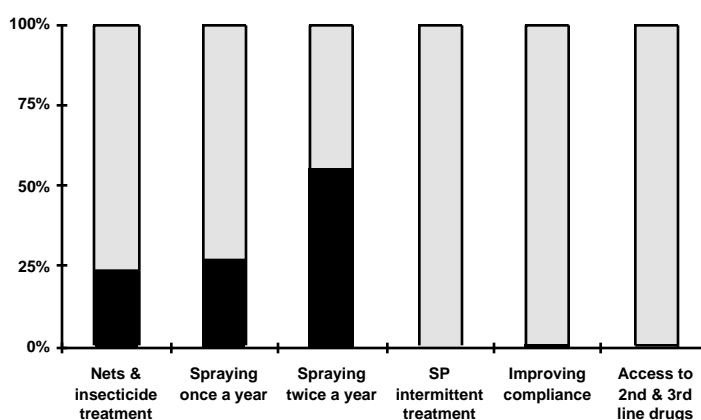
It is important to note that cost-effectiveness analysis is concerned with the unit cost of achieving a health effect. The total cost of implementing an intervention will depend on the extent of the problem to be tackled and the population coverage sought. To give an idea of the affordability of each intervention, we calculated the total cost of full coverage of the population at risk in a typical very low income country, and expressed it as a percentage of the funds available to the government for health (Figure 6). Some interventions were relatively inexpensive: prevention in pregnancy, improving compliance with treatment, and improving the availability of second and third line drugs would each absorb less than 1% of the existing budget. However achieving high coverage with an intervention to prevent childhood malaria could have an extremely high total cost. For example, full coverage of children under five with the provision and treatment of insecticide treated nets would cost the equivalent of 24% of the existing health care budget, though if insecticide treatment only were required, this would take up around 3%. The same coverage with residual spraying would be even more expensive, costing the equivalent of around 27% of the existing budget with one round per year, and 55% with two rounds.

Figure 6: Affordability to government: cost of full coverage as % of current health expenditure

In the face of many pressing coverage as % of current health expenditure priorities and limited resources, a package of interventions which would significantly reduce the bulk of the malaria burden is evidently not affordable to very low income countries through government finance alone.

While there is scope for increased private sector involvement, it is clear that the

most vulnerable and impoverished groups in Africa will not be reached with effective prevention and treatment without substantial external assistance.



This analysis also has a message for malaria researchers and funders. It highlights key gaps in the research evidence required to underpin Roll Back Malaria. For several of the interventions the data are particularly poor: there is no up-to-date information on the health benefits of residual spraying; the effectiveness and costs of chemoprophylaxis for children were derived from a single study; and very few studies are available on treatment interventions. The results

of the analyses of antenatal prevention and interventions to improve treatment are dependent on extrapolations from intermediate outcomes such as birth weight and compliance to final health outcomes; these relationships have not yet been validated empirically. The lack of data prevented analysis of several potentially important interventions, including environmental management, epidemic surveillance and prevention, and interventions to improve the treatment of severe malaria. All these require attention from researchers and funders. Operational research is also vital if the cost-effective interventions are to be tailored to local circumstances and delivered equitably, efficiently and effectively.

Acknowledgements

Anne Mills is Head of the Health Economics and Financing Programme at the London School of Hygiene and Tropical Medicine, which receives a programme grant from the UK Department for International Development.

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Kirigia, J. M., Snow, R. W., Fox-Rushby, J. & Mills, A. 1998 The cost of treating paediatric malaria admissions and the potential impact of insecticide treated mosquito nets on hospital expenditure. *Tropical Medicine and International Health* 3, 145-150.

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BREAKOUT SESSIONS: ECONOMICS OF MALARIA

Programme

1. Demand for Malaria Treatment and Prevention.

Chair: Professor Anne Mills

Rapporteurs: Catherine Goodman and Omer Mensah

Report reviewers: D Filmer, C Goodman, K Hanson, O. Mensah, A Mills, P Mujinja

Aim:

- Share information on research in progress and planned.
- Suggest research agenda on economics of malaria.
- Provide the opportunity for African researchers to present work in progress or recently completed.
- Identify capacity development needs.

Content: 10-minute presentations of papers. Substantial discussion time.

1. Willingness to Pay for Insecticide Treated Bed Nets for Malaria Control: A Case of Bagamoyo Bednet Project - Phare Mujinja.
2. Willingness to Pay for Insecticide Treated Nets Before and After Implementation of ITN in a Semi-Rural District of South Mozambique - Martinho Dgedge.
3. Willingness to Pay for Insecticide-Treated Nets in 5 Nigerian Communities - Obinna E. Onwujekwe.
4. Is Money the Only Problem? Constraints to Net Ownership in Rural Tanzania - Romanus Mtung'e.
5. Availability and Affordability of Insecticide for Treating Bednets in The Gambia - Jane Rowley.

Research agenda on:

- willingness to pay
- willingness to pay methods
- determinants of demand

2. Supply Issues and Markets

Chair: Professor Anne Mills

Rapporteurs: Catherine Goodman and Omer Mensah

Economic analysis of interventions

1. Using Mathematical Tools to Predict the Economic Costs and Benefits of Malaria Control Interventions - Eve Worrall.
2. Modelling the Cost-Effectiveness of Malaria Control Interventions - Catherine Goodman.
3. A Cost Analysis of First-Line Mild Uncomplicated Malaria Treatment in the Tonga District of Mpumalanga - Justin Wilkins.

Research agenda on:

- cost-effectiveness analysis
- value of modelling approaches to CEA
- delivery strategies

Market analysis

1. Markets of Malaria Prevention and Control Commodities: Towards a Framework - Kara Hanson.
2. How can national Malaria Control Programmes in Africa act to maximise the public health utility of commercial markets in nets? The Tanzanian example and the advantages of a 'catalytic' approach - Jo Lines.
3. The social marketing of Insecticide treated nets in Tanzania; a strategy for expansion - Jane Miller.

Research agenda on:

- the operation of markets for malaria related commodities
- the best way to promote sustainable markets for products such as nets and insecticides
- the effects on the poorest of market-orientated strategies

3. Public Policy

Chair: Germano Mwapu

Rapporteurs: Catherine Goodman and Omer Mensah

1. Public economic aspects of malaria control - Deon Filmer
2. Effective malaria control: the political, economic and institutional constraints - Caroline Sergeant.
3. Impact of health care financing reforms on the management of malaria in Ghana - R. Biritwum.

Research agenda on:

- role of government in various aspects of malaria control
- political, economic and institutional constraints to effective malaria control
- effect of health sector reform on malaria control
- approaches to reform and elements of reform that best support effective malaria control

Summary Report: Economics of Malaria

Introduction

Whilst a number of scattered studies have been done on the economics of malaria in Africa in recent years, this was the first time that economists working on African malaria had been brought together, and the conference thus represented a landmark in the development of a group of researchers creating a body of knowledge on this topic. The identification of economics as a session topic was greatly appreciated, and enabled much needed interaction between economists and control staff.

The presentations and discussions were organised into three sessions on firstly the demand for malaria prevention and treatment, secondly supply issues and markets, and thirdly public policy. The sessions were very well attended, and featured a number of presentations by African economists who are keen to continue to work in this field.

1. Demand for Malaria Treatment and Prevention

This area covers the consumers' perspective – why, where and how people seek prevention and treatment? Key questions considered were:

- What methodological approaches can be used to obtain information?
- What have we learnt about factors influencing demand?

There are two ways of analysing demand: firstly studying actual purchases, and secondly undertaking Willingness-To-Pay (WTP) surveys, where potential customers are asked hypothetical questions about the amount they would be willing to pay for commodities. As some malaria control tools, such as nets and insecticides, are relatively new products in some communities, the WTP method has been advocated to predict and analyse potential demand.

Several studies were presented on the demand for nets and insecticides in Africa which had been designed to test the methodology of WTP studies. The researchers raised several reasons why WTP estimates were not always good predictors of actual purchase, including growth in public awareness about nets between the survey and time of sale, and strategic behaviour by respondents who were trying to influence the price set by the programme. In view of these problems, further work is needed on assessing both actual and potential demand.

Several studies found a clear relationship between socio-economic status and WTP for nets, and households clearly face many other competing demands on their income. Whether a price is charged and the level of this price has implications for affordability for the poor. In addition, as the price set affects coverage levels, it may also influence the effectiveness of interventions if they depend significantly on a mass killing effect and therefore need to have relatively high coverage to have a major impact on health.

Other factors highlighted in discussions as affecting demand and meriting further investigation included:

- Seasonality of the availability of income
- Low levels of awareness about the transmission of malaria and unfamiliarity with the intervention
- Gender roles in the household – in some settings women were more aware of the benefits of interventions, but men controlled expenditure for large items such as nets

- Accessibility and availability of products – in some cases this was a crucial factor for both nets and insecticide.

Analyses of this type can feed into the design of interventions. Further work is needed to explore the scope for several strategies including:

- Use of credit, and potential for linking with existing community micro-credit schemes
- Seasonal payments, which allow people to pay at times of the year when income levels are highest, such as the harvest
- Targeting subsidies on the most vulnerable groups, and thinking about issues related to “leakage” to less needy groups
- Targeting messages to household members responsible for expenditure decisions
- Strategic points for net distribution and sales to stimulate potential demand.

Analyses have to date focused mainly on ITNs. More work is also needed on the demand for other preventive commodities, such as insecticide retreatment products and services, and for curative services.

Conducted at a relatively low cost, the set of WTP studies demonstrated the value of a targeted effort to answer specific questions through a cluster of studies in different countries. These studies need to be finalised and made available more widely. The potential for other areas to benefit from such targeted research needs to be considered.

2. Supply Issues and Markets

This session had two themes: A) cost-effectiveness of interventions and B) analysis of markets.

A. Cost-effectiveness of Interventions. Cost-effectiveness analysis is an important tool for decisions on resource allocation, but very few cost-effectiveness analyses on malaria control are currently available. This has necessitated the use of modelling techniques to estimate the cost-effectiveness of interventions. Several papers were presented on this topic, raising a number of points :

- Highly cost-effective interventions exist to help control malaria; there are clearly many problems in their implementation, but effort can be justified on the grounds that they are good value for money.
- The most cost-effective mix of interventions will vary from place to place, depending on the level of existing infrastructure, input prices, the scale of activity, epidemiological and demographic factors, acceptability to local people, and capacity to implement an effective programme.
- There is a paucity of information on costs and effectiveness in operational settings (as opposed to trial conditions). A particularly important example is the lack of information on the relationship between the coverage of ITN projects and the existence of a mass effect, meaning that the effectiveness of ITN projects at the low levels of coverage often found in operational settings is not known.
- Estimates are not available of the cost-effectiveness of a mix of interventions implemented simultaneously. For example, the same population could use ITNs and chemo-prophylaxis, but information is available only on the cost and effects of each intervention implemented alone.

- It is important to consider how the cost-effectiveness of interventions will change at different scales: the benefits of economies of scale may be reaped, but it is also possible that diminishing returns will set in, increasing the importance of using a mix of interventions.
- More work is needed on comparing the cost-effectiveness of alternative delivery strategies for a given intervention to maximise the efficiency of resource use.
- In modeling cost-effectiveness, uncertainty about parameter estimates is a major concern. Cost-effectiveness studies should identify the key variables causing that uncertainty, so that research can be targeted at these issues.
- Research is needed on the cost-effectiveness of interventions in areas of unstable transmission.

B. Analysis of markets. There is a growing recognition that the private sector is an important source of prevention and treatment, and that the public and private sectors influence one another. However, relatively little is known about the operation of the private sector, or how public policy can be used to improve its performance in achieving public health goals. A general theme of the session was that to take into consideration market failures and design appropriate interventions it was necessary to take a market perspective. This involves developing an understanding of household behaviour in relation to purchase, and supplier behaviour in relation to provision. Several presentations focused on how best to develop markets for ITNs, raising a number of points:

- There are likely to be problems in scaling up subsidised programmes; as publicly run programmes are unlikely to be more efficient than the private sector, a subsidy will need to be maintained which will be unaffordable on a national scale.
- Strategies to expand ITN coverage through the commercial sector must balance the development of a sustainable and competitive commercial sector with issues of equity of access to goods of public health importance.
- Strategies such as product differentiation should be explored to investigate the potential to effectively target subsidies on those who cannot pay the market price.
- There is a risk that the promotion of subsidised products will crowd out commercial initiatives, and so impede the development of private markets. On the other hand, subsidised promotion may lead to a 'halo effect', meaning that commercial market development is stimulated both within and outside the project area.
- The effect of branding on the market structure must be considered.
- The markets for commodities, such as nets and insecticide, are very different, and therefore their promotion may require quite different approaches.
- Further thought needs to be given to markets for other commodities, particularly drugs. This is very high priority given the substantial size of private drugs markets.
- There is a need for further development of tools for assessing both market supply and demand.

3. Public Policy

There is a strong economic rationale for some kinds of public intervention in malaria control due to the presence of several market failures (including public goods, externalities and asymmetric information), as well as equity concerns.

However, there may also be government failures which need to be addressed. There are a range of social, economic, institutional and political constraints to the implementation of

effective malaria control. Financing mechanisms are weak, and personnel often lack incentives to perform well. Ministers may be unaware of what is going on at the grass roots, while political commitment is often lacking at the district level and below, and the role of local government is rarely considered.

Successful implementation of control strategies will be dependent on an understanding of the constraints faced and a serious attempt to address key problems. This will require input from a range of disciplines, including political science, to explore the influences on resource allocation and the problems of getting evidence into action.

A key question is 'How should governments intervene?' This could take a range of forms, incorporating provision, financing and regulation. Several points were raised under these themes.

- Provision

We need to consider how malaria interventions can be linked and integrated with existing services for other health problems. The appropriate mix of public and private providers must be explored, and the potential interactions between the private and public sectors considered. Work is needed on approaches to improve the efficiency and quality of public sector health services.

- Financing

Cost-recovery should be assessed in terms of its impact on the behaviour of providers, and on its implications for efficiency, equity, access and quality. More sophisticated analysis is needed of incentives facing public and private providers, and how these affect their behaviour.

- Regulation

This is a key research priority – the roles of professional bodies, government agencies and the community need to be explored.

Research Priorities

In the time available it was not possible to consider and agree on a comprehensive research agenda, but a number of key priorities for health economics research were highlighted.

1. The economic burden of malaria

- Link between poverty and malaria

2. Public policy

- Issues of regulation (government, professional bodies, etc.)
- The implications of a range of cost-recovery strategies for cost, quality and access
- Political science research on political and institutional constraints to policy implementation

3. Demand

- Analysis of the predictive value of alternative elicitation mechanisms for WTP studies, and the impact of information provided or methods used on responses
- Studies of consumer preferences and allocation of household resources

4. Analysis of supply issues and markets

- Development of a framework which will assist thinking about the role and behaviour of markets for malaria related commodities
- Evaluation of behavioral and market impact of different types of interventions

5. Cost-effectiveness analysis

- How should regional variations in epidemiology be used in the design of control interventions? What level of detail on risk variations is required to cost-effectively target control measures? For example some policies would be more appropriately applied nation-wide, but others might be left to districts to decide. Collaboration between epidemiologists and economists will be essential to address this issue.
- Generation of information on the costs and effects of interventions in operational settings
- Analysis of the cost-effectiveness of a package of interventions
- Comparison of alternative delivery strategies for interventions (e.g. different methods of net distribution and treatment)
- Analysis of particular interventions – drug regimens (in particular combination therapies), diagnostics, herbal remedies, control strategies in areas of unstable malaria

6. Design of new malaria control tools, such as drug therapies, vaccines and diagnostics

- Social science and economics should be used to influence the design of new tools, and not just brought in to help deliver interventions once developed.

In addition it was highlighted that social science disciplines other than economics have a vital contribution to make to Roll Back Malaria. In particular, an understanding of people's social and economic behaviour is essential for the design of appropriate interventions. It was concluded that future meetings should include the opportunity for other social scientists to have similar discussions.

Implication of Research Results for Treatment or Control of Malaria

- Market failures justify some kinds of public intervention, but this may take several forms including provision, financing, regulation and information provision.
- The design of interventions by governments and NGOs should take a market perspective, considering the impact of strategies on the actual and potential supply in the public and private sectors.
- The effect of cost-recovery mechanisms on the behaviour of providers and households must be carefully considered.
- The design of delivery strategies should be based on a detailed understanding of the binding constraints on purchases, and a recognition that these are not purely monetary.
- Highly cost-effective interventions are available for both the prevention and treatment of malaria; the most cost-effective package in a particular setting will vary depending on both epidemiological and socio-economic conditions
- There is an important role for cost-effectiveness considerations in the planning process at national and local levels.

Strengthening Links between Research and Control

To date the contribution of economic analysis to the design of malaria control strategies has been limited, partly because the body of work available is still quite small, and partly due to problems of communication.

There is a need for an ‘interpreter’ to translate the evidence provided by researchers into terms that can be easily understood and utilised by control personnel and decision makers. This will require greater dissemination efforts on the part of researchers, and also capacity building among members of the control community. A specific mechanism or unit may be required to interpret and transfer information.

There is also a need for greater links between researchers from the social science and science fields.

Identified Research Capacity Needs (Human Resources)

There is a dearth of African economists working in the health field for several reasons:

- Health economics is a relatively new field of economics, and most African economists are not trained in this area.
- Poor remuneration and conditions of service cause a brain-drain of economists away from the public sector, where most health economics posts are based, and some of the best health economists are attracted away to work for international agencies.
- The low number of health economists and the lack of understanding and appreciation of the role of economics among other health personnel, make it difficult for health economists to work effectively.

It was also noted that the health economists who are available are often not well utilised and are not involved in the policy making process and the design of programmes.

Several approaches were identified to develop health economics capacity:

- The WTP studies presented were excellent evidence of the value of a focussed approach to developing knowledge on a particular topic, involving a call for proposals, a workshop to help develop proposals, and support to researchers. Such research is not costly to do, and has high pay-offs in terms of knowledge generation and capacity development
- Small workshops are very effective for training and networking
- A network of African health economists working on malaria should be encouraged
- African health economists need improved access to information on current research, and obtaining grants
- The curricula of graduate economics courses is often inappropriate for the applied work health economists undertake in Africa
- Resources are required to upgrade the skills of middle level health economists, so they can perform a more senior role.

It is not only health economists who are lacking – there are also very few trained personnel in other social science fields and this issue also needs to be addressed.